Astigmatism experts clarify some of the most challenging aspects of modern refractive surgery and offer pearls to improve the measurement and treatment of this disorder.

EW DIALOGUE

Challenging cylinders: Optimizing astigmatism assessment and treatment

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Marguerite B. McDonald, MD: Why don't we start describing the most misunderstood concepts regarding the way surgeons approach and treat astigmatism today?

David R. Hardten, MD: I think that most of the time, we assume that astigmatism is regular astigmatism. We still tend to think that a spherocylindrical correction is optimal. All our reasonable treatment methods correct spherocylindrical methods. We don't really understand what happens when it's not exactly spherocylindrical.

Kerry D. Solomon, MD: I see cataract surgeons often ignore astigmatism, and they may not get uncorrected visual outcomes as good as they would like. I think people need to approach smaller amounts of astigmatism (1 D, 1.25 D) that they might otherwise ignore.

With excimer, I often hear people say, "Well, in the initial photorefractive keratectomy studies, people considered 1 D or less to be clinically insignificant." We've found that isn't really true.

Robert M. Kershner, MD: For most practicing ophthalmologists, it has been a long time since they studied basic optics for the Board exam. As a result, many do not understand the basic concepts of ocular optics that impact the theories behind astigmatism treatment.

Astigmatism simply refers to more than a single point of focus upon the fovea. If one meridian of the cornea is steeper than the other, then it will focus more strongly and in front of the retina, creating a blur. Surgeons should understand the concept of steep meridian. The highest plus meridian power of the cornea is the area that needs to be flattened.

McDonald: Do you think that in the next 5 years or so we'll be able to routinely go beyond 20/20?

Johnny L. Gayton, MD: I see no reason why we shouldn't achieve better than 20/20 with newer-generation topography units, understanding more about astigmatism, and marrying that topography unit with the excimer laser and other astigmatic correction modalities.

Solomon: I would hope that we would get beyond 20/20 too. I think the eye system is wired to see better than 20/20. We just can't routinely assume that it's all built into the cornea. And we shouldn't just focus our treatments on what the surface topographers are going to give us. Things like wavefront technologies allow us to look at the refractive power of the eye as a whole.

Refraction vs. keratometry

McDonald: Let's talk about when a surgeon encounters a patient with a different amount of astigmatism, either magnitude or axis, between the refraction and topographic analysis. How do you deal with that?

Louis D. "Skip" Nichamin, MD: The real issue has been, through the years, the difference between conventional keratometric measurements and refraction.

My work has indicated that we need to focus more upon the quantity of cylinder and refraction rather than keratometry. However, I've found that keratometry and topography may more reliably detect the steep meridian. And topography is the classic tie-breaker.

We don't necessarily have to eliminate all astigmatism. At least for the cataract populations, you want to get that level down to 0.5 D or so and not make them worse.

Noel A. Alpins, MD: There are two fundamental ways to measure astigmatism in the human eye — these values are derived from either the manifest refraction or the corneal shape. Until now, all treatments have been based on one or other of these measurement modes. When you treat at either one or other extreme (totally refractive or totally corneal), there's going to be some astigmatism remaining at the other level when differences exist. Without going through the numbers, you can find upward of 30% of the patients end up with an adverse result at a refractive level if you treat by topographic parameters alone, or a less than optimal corneal outcome if you treat by only refractive astigmatism values.

Arturo S. Chayet, MD: When I do a keratorefractive procedure, I only use the manifest refraction cylinder. When I do intraocular surgery, specifically cataract surgery, I only rely in the cornea astigmatism, the keratometric measurements. I believe that most of the astigmatism in the eye of the optical system is in the cornea and in the lens. I don't see how we can get astigmatism from other sources. Maybe we can get some irregular astigmatism by having a malpositioned intraocular lens. But if the intraocular lens is very well-positioned, I don't see how we can get astigmatism from other sources above the cornea.

Hardten: I've definitely seen some patients who have posterior corneal astigmatism that seems to be significant. Some of the patients have a significant increased prominence of their anterior Schwalbe's line. Posterior embryotoxin will sometimes be associated with a high posterior corneal astigmatism, where the refractive astigmatism won't totally agree with the keratometric; or refractive and anterior surface topography correlations will not be exact. These eyes may have more astigmatism on the posterior surface of the cornea.

Some patients also have unusual refractions, in that they have staphyloma or an abnormal curvature in the area of the macula, where they can get some retinal astigmatism. You may be able to pick up these problems by ophthalmoscopic examination.

Chayet: Yes, but those are probably the exceptions, not the rules.

Hardten: Right, but the exceptions are the problem patients we would like to help.

McDonald: Do we think vector analysis is necessary to understand and assess astigmatism?

Alpins: Vector planning, which addresses the analysis prior to surgery, enables you to incorporate refractive and topographic values into the surgical plan. It does this by looking at the outcome of the surgery based on those two preoperative values avoiding the exclusion of one or the other. You have to accept that there will be some astigmatism remaining after treatment. The key to optimal astigmatism surgery is how to deal with this remaining cylinder.

McDonald: What do you think the impact of wavefront technology on the accuracy of our refractions and the assessment of the cylinder will be?

Nichamin: It would appear as though, based on the basic science, to have the potential to revolutionize the subject.

Alpins: Yes. Wavefront technology has achieved for the manifest refraction value what topography did for keratometric values. It's just like getting a refractive map of the eye. And it's basically given you potentially a better set of refractive numbers. But if you don't consider the topographical shape in the astigmatic treatment plan, you're just leaving all that remaining astigmatism on the cornea and reproducing any optical aberration within the eye on its surface to try to correct it.

Potentially, you could increase the cornea's irregularity by treating purely by those 50 to 150 differing refractive values.

McDonald: How does non-Placid technology fit into this picture?

Hardten: I think we're still going to need to be able to identify, with our surgical treatments, what we have done to the cornea. I think you can use that as a measure of what's actually done. Look at a topography, see what it did before and after refractive surgery, and use that information in concert with wavefront technology to see what you've done to the refractive state of the eye.

Kershner: Topographic analysis and the new Orbscan are powerful tools in allowing us to analyze the corneal astigmatism. Surgeons have to recognize, however that the cornea is simply one component of the complete optical system of the eye. Aberrations within the lens and the posterior pole further contribute significantly to refractive error. When corneal topographic analysis fails to reveal astigmatic measurement by refraction, we typically will not plan astigmatic surgery until after lens removal to assess the contribution of a cataract and the posterior pole.

Treatment scenarios

McDonald: Who's got some pearls about regular myopic astigmatism for the reader?

Solomon: Treating the manifest refraction, at least in terms of cylinder, in myopic astigmatism, tends to be the most predictive. I tend not to pay as much attention to the cycloplegic astigmatism refractive power.

Chayet: Always think "minus cylinder"; have all the notes on minus cylinder. I keep receiving calls and referrals from surgeons around the United States and Mexico, where a technician puts the cylinder 90° away, because in America, most of the cornea surgeons or most of the ophthalmologists were used to notes with plus cylinders. And when they go to the excimer cylinder, most of the calculations are done with minus.

Gayton: The most common astigmatic error that's made in astigmatism correction is a 90° away error. We avoid that by positioning the topography exactly the way the patient's eye is positioned and verifying one more time right before doing the procedure.

McDonald: Any tips about marking the astigmatism before laser in-situ keratomileusis?

Alpins: I am not aware of any studies that demonstrate any significant benefit.

Solomon: I think it's absolutely necessary. I set them up 90° and I mark them with a blue marking pen. I know you can do it in one meridian, but I do it in all four — 6, 12, 3, and 9 o'clock. And when I lay them down, I'm often surprised at how much torsion I've seen. I'm a big believer in marking.

Alpins: There has been an overstatement in the amount of loss of flattening effect you get with off-axis treatments. My understanding is that you actually lose only 15% when you're 15° off and don't lose 50% of the flattening effect until you're 30° off. You lose it all at 45° off.

Hardten: There's also the fact that we use horizontally and vertically oriented letters for our eye-testing charts, rather than round letters.

If I see a topography at 75° and the refraction at 90°, I recheck the topography to make sure the patient's head was aligned properly. I also go back to the refraction and see if I can achieve the same visual results with a refraction on round letters.

McDonald: How about irregular astigmatism? Right now, customized ablations aren't available except in clinical trials; what kind of pearls can we give our readers about dealing with it now?

Chayet: With irregular astigmatism, do not do LASIK, maybe do PRK, but definitely do not do LASIK. Other surgeons are attending patients who already have ectasia from treating 30 µm of ablation for irregular astigmatism. We are making those corneas unstable.

In other words, the keratectomy from the microkeratome cut made that cornea more unstable. To me, it's an absolute contraindication to do LASIK in any type of asymmetric or non-orthogonal astigmatism.

McDonald: How about mixed astigmatism?

Chayet: I've been doing bi-toric LASIK for almost 3 years for mixed astigmatism. The rationale is to flatten the steep meridian at the same grade as we are steepening the flap meridian. With bi-toric ablations, we treat the positive cylinder by steepening the flat axis and flatten the steep meridian with the negative cylinder. That way, we can prevent the induction of spherical corrections.

Solomon: With mixed astigmatism, incisional surgery is a solution, at least in the United States, depending on spherical equivalent.

In terms of treating it all with laser, it looks like cross-cylinder techniques are going to give you your best bang for your buck and save you some depth, because you don't use as many microns, but that's just not approved yet in the United States.

Nichamin: With intralimbal, peripheral, arcuate relaxing incisions, our coupling ratio is pretty close to one to one and our spherical equivalent shift is acceptably close to zero. It's a terrifically easy and forgiving way of decreasing astigmatism, if not eliminating it.

And this harkens back to the comment that was made before about irregular astigmatism. I think our primary responsibility is not to create irregular astigmatism, at least until we have better modalities of treating it. It's my belief that by moving out to the periphery, with regard to incisional astigmatic surgery, we get into a whole lot less trouble with regard to properly centering upon the steep meridian creating an overcorrection or inducing irregular flattening. I think that this form of astigmatic keratotomy also brings astigmatism surgery into the purview of the general, comprehensive ophthalmologist. It's not a particularly demanding or difficult procedure. More patients, hopefully, can get in under that important 0.75-D level.

Kershner: I have been a strong proponent of incisional keratotomy for correction of astigmatism and have found it to be most effective when combined with clear corneal cataract surgery. By using small (3 mm or less) arcs at optical zones of 10, 9, and 8 mm we can correct most forms of astigmatism. In combination with toric intraocular lenses, our ability to correct astigmatism with cataract surgery is now complete.

McDonald: And how about hyperopic astigmatism?

Alpins: Well, you need to treat the hyperopic astigmatism with a flat-axis ablation. Don't try to treat it with any myopic astigmatic correction, by doing treatment at the inner zone and combining this with hyperopic sphere — the result is excess ablation and ineffective treatment of the astigmatism. You want to do the treatment all at the outer zones and combine it with the spherical hyperopic ablation.

Non-excimer treatment options

McDonald: Let's give a few comments about intracorneal ring segments, laser thermal keratoplasty, clear lensectomy, and toric and phakic IOLs. Let's start with intracorneal ring segments.

Chayet: We've been doing some clinical trials with smaller or shorter arc cord length segments. So far, the studies are encouraging, although we need more cases and longer follow-up.

When you place the incision over the flattest meridian, you might have less risk of inducing astigmatism. In other words, one of the problems now is when you go and do the incision at 90°, you may end up with an induced with-the-rule astigmatism.

McDonald: Does anybody have any experience treating astigmatism with LTK?

Chayet: You can usually treat very high amounts of cylinder. But, unfortunately, all the correction goes away within 2 years. In my experience, the treatment of astigmatism is not good. One day you operate at 4 D and the next morning you're at 14 D in the opposite meridian. It's very unreliable.

McDonald: The international data on conductive keratoplasty (which was collected in Mexico) was very encouraging for the treatment of hyperopic astigmatism. We have not started U.S. hyperopic astigmatic protocol yet, but plan to start very soon.

How about clear lensectomy?

Alpins: With clear lensectomy, you often get a very pleasant surprise, because you might get a very large reduction in the refractive cylinder that was not evident in the corneal changes. It's a very effective way of treating a high refractive astigmatism associated with high refractive errors.

McDonald: How about phakic IOLs and astigmatism?

Alpins: It has a very high incidence of needing a secondary procedure, either for the astigmatism or the sphere, perhaps by doing LASIK as a secondary procedure. If you are using a phakic IOL with the astigmatic correction within the lens, you're only addressing the refractive astigmatism and leaving any remaining astigmatism on the cornea. The light entering the eye has to suffer the distortions associated with the passages of two astigmatic surfaces.

Chayet: The early studies we had on toric implantable contact lenses are very encouraging. We're looking forward to starting implanting toric ICLs in the very near future. It seems like it's going to solve many problems, especially for the extreme ametropias that have high astigmatism.